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# Quest for the Best: How to Measure Central Bank Independence and Show its Relationship with Inflation

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**Abstract** The objective of this paper is to check measures for explanatory power of central bank independence (CBI) in a series of econometric tests. Measures of central bank autonomy offer a useful expression of the extent to which a central bank is able to keep the government away from influencing a change in the inflation rate. The more a measure represents this idea, the easier one can find a relation between the CBI value and the inflation rate. Results of estimations show that proxies by Grilli et al. (1991) are strong regressors of inflation rate, contrary to those by Cukierman et al. (1992). Moreover, estimation results challenge the belief that divergences in CBI-inflation rate estimations are due to differences in institutional features across samples of countries, not to differences in legal proxies of central bank independence. Already results from a homogenous group of industrial countries indicate that some indices perform "better" than others.

**Keywords** Central bank independence, political autonomy, economic autonomy, institution, estimation
**JEL classification** E58, E52

## 1. Introduction

The objective of this paper is to check measures for explanatory power of central bank independence (CBI) using a series of econometric tests. These tests are in the spirit of the belief that each institutional improvement of central banks always aims to obtain more efficient monetary policy. Therefore, as found by other studies, it is believed that the main, and perhaps the only, reason to introduce higher degree of central bank independence is to help achieve a lower inflation rate. This paper's title, "Quest for the Best", seems to suggest a winner of this "competition"; that is, the most accurate and adequate measure. However, it is already understood that all measures are vulnerable to criticism. Therefore, there really is no "perfect" outcome for this experiment.

Another aim of this paper is to challenge Cukierman's (1992, p. 425) conclusion that: "any divergences in results between our full sample and that of the ATC [Alesina, and Grilli, Masciandaro and Tabellini studies] is due to differences in institutional features across the samples of countries, rather than to differences in the legal proxies of CB independence." Although one can agree with Cukierman that institutional development of countries matters, it may be possible to see that some measures are even

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stronger predictors of inflation rate than others that have the same sample under investigation.

This paper is organized as follows: Section 2 presents a brief theoretical background covering simple justification for central bank independence. The description of the model, methodology of estimation and the type of data used can be found in Section 3, which is followed by the estimation results (Section 4). Section 5 concludes the paper, with additional information provided in the Appendix.

## 2. Theoretical background

The theoretical and empirical discussion on central bank independence describes the phenomenon in a two ways. The first characterizes determinants of central bank independence, and focuses on required institutional development of the country that helps the bank succeed in obtaining monetary goals. The second method attempts to quantify degrees of CBI around the world and search for a relation between a level of CBI and economic variables.

Determinants of central bank independence can be affected by the nature of political and legal institutions, as well as by a nation's accepted practice, culture and personalities. Among political and economic determinants, one can mention the role of the equilibrium or natural rate of unemployment, the stock of government debt, political instability, the quality of supervision of financial institutions or financial and public opposition to inflation. As Eijffinger and de Haan (1996) explain these determinants are not necessarily mutually exclusive and may partly overlap.

Some studies have presented and proven the hypothesis that the type of political system and its structure determines the presence and degree of central bank independence. First, Moser (1999) shows that the legal CBI is significantly higher in those Organisation for Economic Cooperation and Development (OECD) countries, where extensive checks and balances were present. Moreover, countries with checks and balances have recorded a stronger negative relation between legal CBI and average inflation rate. Similarly, Keefer and Stasavage (2001) empirically show that central bank independence will prove more effective as a commitment mechanism in countries with multiple veto players in government. There is also an indirect effect of checks and balances. The turnover of central bank governors is reduced when governors have tenure protections supported by political checks and balances.

The importance of financial and public opposition to inflation is studied by Posen (1993a, 1993b), who finds that a central bank is successful in its anti-inflationary policy when there is a coalition of interests, like the financial sector, that can protect this aim. On the other hand, the public's preferences, or an accepted practice in a country, seems to be as important as previously mentioned determinants of central bank independence. A thorough investigation of the link between societies' aversion to inflation, a country's inflation performance and the degree of central bank independence can be found in Hayo (1998). According to this study, public acceptance of the need for price stability may be as important as having independent monetary authorities.

Along the work on CBI determinants, a rather extensive research was held on quan-

tifying the degree of independence among the world's central banks. This part of research started in the late 1980s with the work of Bade and Parkin (1988), and later Grilli et al. (1991) and Cukierman et al. (1992). Recently, Eijffinger and de Haan (1996) and Arnone et al. (2006), among others, provide a detail survey of CBI measures, whereas Klomp and de Haan (2010) present a meta-analysis of publications based on CBI studies.

The idea of independence measures lies in identifying presence of certain CBI attributes that may define this phenomenon. Legal measures are constructed of attributes from several groups relating to a central bank's governor, policy formulation, policy objectives, ability of government to borrow from the central bank and external monetary relations of the central bank. A major assumption behind these measures depends on attaching a numerical value to selected central bank institutional factors, which constitute the power and ability to conduct monetary policy.

Despite the same methodology, these indices differ in the choice of CB attributes and their weighting, and sometimes in the final degree of CBI. The measures' construction methodology have been under severe criticism, especially by Forder (1999, 2005), who points out that many CBI indices have, in fact, different understanding of what could be the key issue of independence. Brumm (2000) criticizes the measure of "actual" independence (turnover rate-TOR), and explains that it might not consider the possibility that a central bank governor stays at his post for a long period (thus giving the impression of a high level of CBI) simply thanks to an agreement with political leaders. In a comparison of two indices, a legal proxy by Cukierman et al. (1992) and Grilli et al. (1991), Mangano (1998) finds that these two indices disagree with each other in nearly 60% of all countries included, in the area of an attribute concerning central bank's ability (legal permission) of purchasing government debt in the primary market. There are few examples of inconsistencies among measures, such as the case of the National Bank of Poland, which scores a high value according to the legal measure of independence but the central bank is rather dependent on the government when the turnover rate of governors, thus another measure, is considered.

Quantifying degrees of central bank independence allows searching for its relation with macroeconomic variables, especially with inflation rate. The 1990s witnessed a series of institutional changes in central banks, aiming at ensuring that monetary authorities are the sole policymaker, immune from political pressure. At the same time, over the past fifteen years, global inflation has dropped from 30% to 3% (based on historical data from IMF's World Economic Outlook, available at www.imf.org). From this evidence, one may assume that a higher degree of independence is conducive to a lower level of inflation. On the other hand, a high rate of inflation is likely to result in a lower level of independence. Therefore, as Cukierman (1992, p. 427) explains it is "conceivable that there is a two-way causality between inflation and the actual degree of CB independence."

Empirical evidence of such causality is also given by Cukierman (1992, p. 429), who shows evidence of a two-way Granger causality between inflation and CB independence, as proxied by governors' turnover. Posen (1993a) argues that the relationship "higher degree of CBI—lower rate of inflation" is not causal, and may be caused

by society's preferences for low and stable inflation. Posen was criticized by de Haan and Van't Hag (1995), who show that Posen's results are confirmed only when the Cukierman's legal indicator is used.

Most empirical literature considers central bank independence an exogenous variable and focuses on explaining some elements of a country's economic performance. For example, cross-country data for developed countries show a negative relation between a degree of central bank independence and inflation, but no correlation with output or employment (e.g., Bade and Parkin 1998; Grilli et al. 1991; Cukierman 1992, ch. 19; Eijffinger and Schaling 1993). These studies have been criticized for using a bivariate type of regressions by Campillo and Miron (1997). Their significant contribution was to include several other explanatory variables like openness, debt-to-GDP ratio or exchange rate regime, along with a untypical economic variable of political instability. The work of Campillo and Miron, among other authors such as Eijffinger et al. (1998), Sturm and de Haan (2001) and many more, inspired the following analysis.

## 3. Methodology

The methodology used in this analysis differs from what is normally presented in papers on this topic. Previous studies relied strongly on cross-country estimations done with a reference to a specific point of time, generally connected to the calculation of the level of central bank independence. These studies do not consider the possibility that the degree of CBI would change over time. The cross-country analysis is thus informative only to the limit of the comparison among countries.

The methodology used in this study "upgrades" previous attempts with the analysis of both cross-section and time-series, hence giving a panel data approach. This is possible thanks to the popularity of the CBI concept that led to recalculation of several measures, updated with the new data on central bank legislation. The composition of data suggests the use of the panel data method of analysis with fixed-effects estimator.

### 3.1 On additional tests

A series of verifying tests can be used either to test regressors (i.e. CBI measures) or to test models. A stepwise selection method can be used as an example for testing explanatory power of independence indices, once they are treated as the only regressors in the model. On the other hand, alternative models (when only one CBI measure is included to the model and stands next to other types of independent variables) can be tested against each other with, for example, tests for non-nested models.

#### 3.1.1 Stepwise selection

A large number of CBI indices allows using a regression with the stepwise selection method. This method "evaluates each variable in turn on the basis of its significance level and accumulates the model by adding or deleting variables sequentially" (Greene 2000, p. 334). In the "forward" method, an initial model is defined that contains only the constant. Then, the first "best" predictor is chosen from those available. It is done

by choosing the predictor that has the highest simple correlation with the outcome. The procedure repeats until all "best" predictors are chosen.

Due to several drawbacks, this procedure is treated here as an additional supplementary test. Its major assumption in this analysis is to treat CBI measures as the only independent variables. High and significant correlation coefficients, the factors that lead to excluding this method, have been received on a limited scale. The method's criteria were based on probability of entering $F \leq 0.50$, and probability of removing from regression $F \geq 0.100$.

### 3.1.2 Testing for non-nested models

In empirical investigations of the relation between the degree of CBI and inflation rate, it is common to have several different models that claim success as empirical explanations of this phenomenon. The key element that often changes is the definition of central bank independence. The idea that drives this study, that is, collecting and comparing several CBI indices, creates a unique opportunity to test and cross-validate these models.

In the case of two models explaining the same phenomenon, when neither of them is a special case of the other, one talks about non-nested models. For example, monetarists would emphasise the role of money in explaining changes in GDP, whereas Keynesians may explain them by changes in government expenditure (Gujarati 2003, p. 530). In the case of CBI analysis, the model is often the same, with the exception of the definition of CB independence. The logic of using a particular CBI index can therefore be explained with tests for non-nested regression models. Relating to this problem, Atkinson (1969) emphasizes that it is important to distinguish a few questions relevant to this problem. For example, if one model is already in use as a predictor, is there any evidence of a departure from it in the direction of a second model? Once a CBI measure is changed, is there any evidence that the models fit significantly differently to the data?

Recent developments in testing non-nested hypotheses have been structured around a common idea of the "encompassing principle" (Mizon and Richard 1986). This principle directs attention to whether a maintained model can explain the features of its competitors (Greene 2000, p. 302). Gujarati (2003, p. 530–533) describes two approaches to testing non-nested hypotheses. The discrimination approach involves choosing between two (or more) models based on criteria such as the following: $R^2$; adjusted $R^2$; Akaike's information criterion (AIC), proposed by Akaike (1973); Schwarz information criterion (SIC), proposed by Schwarz (1978). The alternative method is the discerning approach that includes the encompassing $F$-test and Davidson-MacKinnon $J$-test (Davidson and MacKinnon 1982). In the method that the $J$-test provides, the idea is that if one model is the correct model, then the fitted values from the other competitive model should not have explanatory power, when estimating that model.

### 3.2 Data

The key element of all of the following estimations is the measurement of central bank independence. There are approximately seventeen original CBI measures:

BP (Bade and Parkin 1988); Alesina (Alesina 1988); GMTO (Grilli et al. 1991), index that divides into political (GMTP) and economic (GMTE) independence; LVAU (LVAW for weighted measure): legal measure constructed by Cukierman (1992) and Cukierman et al. (1992), and its modification for transition countries LVES by Cukierman et al. (2002); TOR and VUL: turnover rate of governors and the measure of vulnerability, Cukierman et al. (1992) and Cukierman and Webb (1995); ES (Eijffinger and Schaling 1993); Distance (Fratianni and Huang 1994); OPCBI (Eijffinger and Schaling 1995); CBI-DF and SIB (Loungani and Sheets 1997); CBI-Account (Lybek 1999); Freytag (Freytag 2003); CBI-Index (Freytag and Masciandaro 2005); PROB (Krause and Méndez 2007).

Table 1 presents a summary of differences in the construction of a few measures. Most columns indicate whether the particular attribute of central bank independence was included in selected measures. The last column, however, is based on a survey conducted among central bankers by Fry et al. (2000), which ranks the characteristics of central banks autonomy according to importance (where 1 is "the most important" and 6 is "the least important").

Some measures have been unified and connected by definition. Hence, there is no measure calculated by Arnone et al. (2006), but their work is used as the update for the Grilli, Masciandaro and Tabellini (GMT) index (Grilli et al. 1991). Similarly, one may find measures of the turnover rate of governors (TOR) calculated by many authors that help to build a long data set for this index. All sources of data have been acknowledged and included in the references.

Defining a dependent variable may cause as many problems as finding a suitable collection of explanatory ones. Many previous studies used the average annual inflation rate as the dependent variable and others introduce different definitions. For example, Cukierman (1992) chose to use a depreciation in the real value of money, defined as $d = \mathit{inflation}_{i,t}/1 + \mathit{inflation}_{i,t}$ (in this study it is also called a "transformed" inflation rate). He claimed that there are several explanations for doing so. First, it better represents the real losses on the holding of money balances. Second, it moderates the effect of outliers with very high levels of inflation. Moreover, rescaling values of inflation rate according to this procedure helps to ameliorate potential heteroscedasticity (as pointed out by Jácome and Vázquez 2005). Eijffinger et al. (1998) performed a sensitivity analysis and, besides the mean inflation, they included interchangeably elasticity and variance of inflation.

The crucial condition for panel data (especially when the first-differencing method is used) is that there must be variation of explanatory variables across time. This fails if the dependent variable does not change over time for any cross-sectional observation, or if it changes by the same amount for every observation (Wooldridge 2003, ch. 13). It is the case in terms of few CBI measures, which were calculated once and do not change over time.

**Table 1.** Similarities among measures

| Attribute/Measure | BP | Alesina | ES | GMT | Legal | FM | LS | Rank |
|---|---|---|---|---|---|---|---|---|
| *Policy responsibility* | | | | | | | | 2 |
| is CB the sole final policy authority | • | • | • | • | • | • | | |
| is this authority not entrusted to the CB alone | | | • | • | • | • | | |
| is it entrusted to G | | | • | | • | • | | |
| is CB given an active role in formulation of the G's budget | | | | | • | | | |
| *Presence of the G's representative in the CB's board* | • | • | • | • | | | | |
| does he has a vote | | | | | | | • | |
| does he has a veto power | | | | | | | • | |
| *CEO and board appointment* | | | | | | | | 4 |
| CEO not appointed by the G | | | | • | • | | • | |
| length of CEO appointment | | | | • | • | | • | 5 |
| CEO allowed to hold other office | | | | | • | | | |
| CEO an expert | | | | | | • | | |
| more than half of the board appointed independently | • | • | • | | | | • | |
| none of the board appointed by the G | | | | • | | | • | |
| length of board appointment | | | | • | | | • | |
| *Financial and budgetary relations between CB and G* | | | | | | | | 6 |
| direct credit facility not automatic | | | | • | • | • | | |
| DCF is at the market interest rate | | | | • | • | | | |
| DCF is temporary | | | | • | • | • | | |
| DCF is of limited amount | | | | • | • | • | • | |
| CB does not participate in the primary market | | | | • | • | • | | |
| discount rate is set by the CB | | | | • | • | | | |
| circle of potential borrowers | | | | | • | | | |
| who decides control of terms of lending | | | | | • | | | |
| *Conflict resolution rules* | | • | | • | • | | • | 3 |
| *Responsibilities for commercial banks supervision* | | • | | | | | | |
| *Locus of legal commitment* | | | | | • | • | • | |
| *Accountability of the CB* | | | | | | • | | |
| *CB controls monetary instruments* | | | | | | | • | 1 |

Notes: BP (Bade and Parkin 1988), ES (Eijffinger and Schaling 1995), GMT (Grilli et al. 1991), Legal (Cukierman 1992), FM (Freytag and Masciandaro 2005), LS (Loungani and Sheets 1997), Rank (Fry et al. 2000)

## 4. Empirical results

The idea of an existing relation between central bank independence and inflation rate originated from studies focusing on a group of major, often OECD, economies. Once this phenomenon was established, further research concentrated their interest on other groups of countries, keeping in mind varying levels of development among them. While explaining levels of inflation rate over time, it seems rational to differentiate all causes according to the type of economy. Therefore, the following analysis divides the sample into industrial, transition (Central and Eastern European), emerging and developing countries. Reports of empirical results follow this division.[1]

### 4.1 CBI among industrial countries

The analysis time span for advanced countries is the longest, and covers annual data for the years 1970–2007. Among many determinants of inflation after World War II, one may point to the breakdown of the Bretton Woods system in 1971, excessive government spending (and thus, growing deficit and debt-to-GDP ratio, which increased money holding) or few oil crises with cost-push inflation effects.

Figure 1 suggests that, for most of the period, an increased in inflation rate was not caused by an increase in the price of oil. Hence, one may eliminate the cost-push as a determinant of inflation in this group. The general estimated model is of the following form:

$$y_{i,t} = \alpha + \beta_1 CBI_{i,t} + \beta_2 X_{i,t} + u_{i,t} \tag{1}$$

Since some data are not available for all country-years, the panel data may be unbalanced. $Y$ is the inflation rate corresponding with the country and a year; it can be changed into a transformed inflation according to the formula given above. $CBI$ is the value of CBI degree, which depends not only on the country or a year, but also on the type of CBI measures used. $X$ is a vector of other explanatory variables, and $u_{i,t}$ is an i.i.d. disturbance.

Besides theoretical grounds, the first choice of regressors was based on a few simple tests of model selection criteria: $R^2$, or standard errors of regression. The final form of the regression for industrial countries is defined as follows:

$$y_{i,t} = \alpha + \beta_1 CBI_{i,t} + \beta_2 y_{i,t-1} + \beta_3 dloggdpcap_{i,t} + \beta_4 openc_{i,t-1} + u_{i,t} \tag{2}$$

Among many regressors, openness and GDP per capita have been chosen. A large part of economic literature describes the relation between openness and inflation that justifies this choice (for example Romer 1993). To avoid simultaneity, a second option-lagged openness-is also considered in the regression. GDP per capita variable, on the other hand, is used here in terms of first-difference to describe the relation between annual differences in this variable and the inflation rate (transformed inflation). Both variables are defined in current prices. One should also notice a lagged dependent variable that is included as a regressor in order to improve autocorrelation. The results are reported as follows:

[1] Group division of countries in Table A1 in the Appendix is based on IMF classification in 2007.

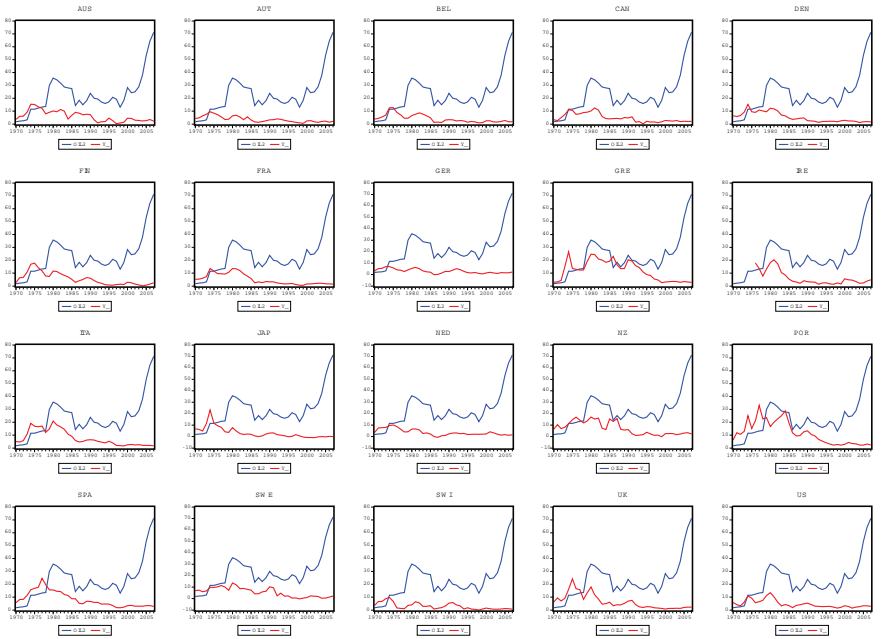



**Figure 1.** Inflation rates and oil prices: advanced countries

(i) Columns represent single regressions differentiated by the CBI measure.

(ii) List of regressors is placed in rows.

(iii) Additional information describes goodness-of-fit of each regression along with the type of methodology.

Models are estimated using stacked pooled data. Estimations are done with the fixed effects and General Least Square (GLS) weights, allowing for heteroskedasticity in cross-section. To compute standard errors that are robust to serial correlation (Arellano 1987; White 1984) one should choose the White period as the coefficient covariance method. Estimated GLS (EGLS) is more efficient, compared to the OLS, once one is willing to make assumptions about the form of heteroskedasticity (Verbeek 2004, p. 95). The standard errors for the GLS approach are much smaller, so there is an estimation efficiency gain.

In Table 2, at first glance, all long-time measures (i.e. those that were calculated more than once) show an expected sign of a coefficient: negative or positive for the index PROB. Only updated values of Alesina (done by the authors of this paper) are insignificant. This could be generated by possible mistakes in calculations, because the data was gathered based on other measures. All other CBI indices seem to be good regressors of transformed inflation. None of the "short-time" measures appeared to be

**Table 2.** Estimation results: "transformed inflation" as a dependent (industrial countries)

| | LVAU | GMTO | GMTE | GMTP | PROB | Alesina2 |
|---|---|---|---|---|---|---|
| CBI | $-0.07^{**}$ | $-0.03^{**}$ | $-0.11^{***}$ | $-0.04^{**}$ | $0.14^{***}$ | $-0.01$ |
| | (0.03) | (0.02) | (0.02) | (0.02) | (0.04) | (0.03) |
| | [−2.87] | [−1.95] | [−4.10] | [−2.43] | [3.3] | [−0.34] |
| $d_{i,t-1}$ | $0.68^{***}$ | $0.70^{***}$ | $0.64^{***}$ | $0.68^{***}$ | $0.67^{***}$ | $0.65^{***}$ |
| | (0.06) | (0.06) | (0.06) | (0.06) | (0.07) | (0.07) |
| d(log)GDP p.c. | $0.69^{***}$ | $0.67^{***}$ | $0.52^{***}$ | $0.63^{***}$ | $0.70^{***}$ | $0.89^{***}$ |
| | (0.13) | (0.14) | (0.12) | (0.13) | (0.16) | (0.18) |
| Openness (−1) | $-0.0005^{**}$ | $-0.0008^{**}$ | $-0.0005^{**}$ | $-0.0004$ | $-0.0005^{**}$ | $-0.0007$ |
| | (0.0002) | (0.0003) | (0.0002) | (0.0002) | (0.0006) | (0.0005) |
| Constant | 0.25 | 0.24 | 0.33 | 0.23 | 0.20 | 0.23 |
| | (0.05) | (0.04) | (0.06) | (0.05) | (0.05) | (0.05) |
| Observations | 715 | 734 | 734 | 734 | 560 | 420 |
| Adjusted $R^2$ | 0.97 | 0.97 | 0.97 | 0.97 | 0.96 | 0.96 |
| S.E. | 0.33 | 0.32 | 0.32 | 0.32 | 0.37 | 0.40 |

Notes: Fixed effects with GLS cross-section weights and White cross-section coefficient covariance method used for all regressions. Coefficients' standard errors in parentheses, and $t$-statistics in square brackets. $^{***}$, $^{**}$, $^{*}$ indicate results significant at the 1%, 5%, and 10%, respectively.
Abbreviations (used hereinafter): LVAU legal CBI index by Cukierman et al. (1992); GMTO, GMTE, GMTP indices by Grilli et al. (1991); PROB index by Krause and Mendéz (2008); Alesina2 updated index originally created by Alesina (1988); $d_{i,t-1}$ transformed inflation rate; d(log)GDP p.c. difference in log GDP per capita; Openness(−1) lagged one period measure of openness.

a regressor that significantly explain changes in values of transformed inflation.

The next step is reestimation of the model with the use of simple inflation rate as a dependent variable. Moreover, for the sake of better goodness-of-fit and understanding of the model, GDP per capita is included in its level logged form (without calculating first-difference). This acts as a first robustness check, a test of whether CBI measures keep their explanatory power when the dependent variable is defined differently and some other regressors change their forms. Table 3 presents the outcome of these estimations:

$$y_{i,t} = \alpha + \beta_1 CBI_{i,t} + \beta_2 y_{i,t-1} + \beta_3 loggdpcap_{i,t} + \beta_4 openc_{i,t-1} + u_{i,t} \tag{3}$$

The model transformation revealed weaknesses among CBI measures. Simple data modification, like a presentation of a dependent variable in its original form, showed that some indices lost their explanatory power. Two measures-overall GMT index and its economic definition-appeared to be again good regressors of inflation rate, being significant at the 5% level (although the latter's coefficient had a much higher standard error). With a "short-time" group of indices (those whose values do not change over time) it was possible to estimate simple cross-country models. The first original measures by Bade-Parkin, Alesina and Eijffinger-Schaling performed relatively well as regressors. They did not only significantly differ from zero, but also had smaller standard errors. Other measures, including TOR and VUL but also measures based on distance from Germany or OPCBI, did not perform well in this test.

**Table 3.** Estimation results: "lagged inflation" as a dependent (industrial countries)

| | LVAU | GMTO | GMTE | GMTP | PROB | Alesina2 |
|---|---|---|---|---|---|---|
| CBI | −1.17 | −0.63** | −1.59** | −0.29 | 1.31 | −0.18 |
| | (0.75) | (0.23) | (0.68) | (0.58) | (0.96) | (0.43) |
| | [−1.56] | [−2.74] | [−2.35] | [−0.49] | [0.96] | [−0.41] |
| Inflation rate(−1) | 0.72*** | 0.72*** | 0.70*** | 0.72*** | 0.79*** | 0.76*** |
| | (0.04) | (0.05) | (0.05) | (0.04) | (0.04) | (0.04) |
| (log)GDP p.c. | −1.75*** | −1.77*** | −1.64*** | −1.8*** | −1.10 | −1.35 |
| | (0.48) | (0.50) | (0.48) | (0.53) | (0.87) | (0.90) |
| Openness (−1) | 0.03** | 0.02** | 0.03** | 0.03** | 0.01 | 0.02 |
| | 0.01 | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Constant | 16.98 | 17.47 | 16.95 | 17.24 | 10.59 | 13.17 |
| | 4.36 | (4.56) | (4.40) | (4.69) | (7.86) | (8.28) |
| Observations | 715 | 734 | 734 | 734 | 560 | 420 |
| Adjusted $R^2$ | 0.82 | 0.80 | 0.81 | 0.80 | 0.84 | 0.83 |
| S.E. | 2.08 | 2.26 | 2.26 | 2.26 | 1.74 | 1.61 |

Notes: Fixed effects with GLS cross-section weights and White cross-section coefficient covariance method used for all regressions. Coefficients' standard errors in parentheses, and $t$-statistics in square brackets. ***, **, * indicate results significant at the 1%, 5%, and 10%, respectively.

Since EGLS makes certain assumption about the form of heteroskedasticity, one can eliminate this assumption and estimate models with a simple Least Squares estimation, keeping fixed effects. This has been performed as well, keeping the original forms of models. First of all, it was not possible to receive the same outcomes in terms of CBI measures. Measures by Grilli et al., overall and economic, kept their strong explanatory power that was significantly different from zero with inflation rate, as a dependent variable (no longer with transformed inflation, however). Obviously, standard errors were higher, but the difference was rather small (0.32 for GMT overall).

### 4.1.1 Some specification tests

From panel estimation, one can notice that coefficients of GMTO measure of independence were for all the tests significantly different from zero, whereas few other measures suffered from robustness, while the dependent variable was redefined. This outcome gives incentive to test whether a model, where the GMTO represents a CBI definition, should be accepted over all other models.

For this reason and assumption, a $J$-test for non-nested models has been performed. In a model with an inflation rate, as a dependent variable and Least Square estimation, all models ("long-time" models) were evaluated in a pair-wise comparison. For example, choosing between two specifications including either GMTO or GMTE followed the procedure below:

$$H_1 : y_{i,t} = \alpha + \beta_1 GMTE_{i,t} + \beta_2 y_{i,t-1} + \beta_3 loggdpcap_{i,t} + \beta_4 openc_{i,t-1} + u_{i,t}$$
$$H_2 : y_{i,t} = \alpha + \beta_1 GMTO_{i,t} + \beta_2 y_{i,t-1} + \beta_3 loggdpcap_{i,t} + \beta_4 openc_{i,t-1} + u_{i,t}$$

If fitted values of $H_2$ enter significantly in model $H_1$, model $H_1$ can be rejected. However, if the opposite happens, and fitted values of $H_1$ are significant when included in

$H_2$, model $H_2$ can be rejected as well. This is a drawback of this method: it is possible to either reject both specifications or fail to reject both models, at the same time. In this case, the data do not provide enough information to discriminate between the two models.

Here, fitted values of GMTO entered significantly into all other models with "long-term" CBI measures (as a reminder: GMTE, GMTP, LVAU, PROB). At the same time, none of these models' fitted values were significant in the GMTO estimation. Additionally, considering other pairs, fitted values of GMTE were significant in the LVAU estimation; but the opposite did not happen.

One other test for the explanatory power of competitive variables is to regress the model that consists of all these elements, for example a model where all regressors are CBI measures. Table 4 summarises outcomes of these tests. The general idea is the same: which CBI measure will be significantly different from zero in a set of many similar definitions. Due to high correlation between GMTO and GMTE (GMTP), the overall index is eliminated. One should note that GMTP and GMTE have completely different definitions and are uncorrelated.

**Table 4.** Results for industrial countries with CBI as the only regressors

| Dependent variable: inflation rate | | | Dependent variable: transformed rate | | |
|---|---|---|---|---|---|
| | (1) | (2) | | (3) | (4) |
| GMTE | $-8.79^{***}$ | $-1.53^{**}$ | GMTE | $-0.40^{***}$ | $-0.15^{***}$ |
| | (1.02) | (0.51) | | (0.03) | (0.04) |
| | [−8.59] | [−2.99] | | [−12.39] | [−3.47] |
| GMTP | $-5.15^{***}$ | −0.63 | GMTP | −0.06 | −0.01 |
| | (1.25) | (0.60) | | (0.04) | (0.02) |
| | [−4.12] | [−1.05] | | [−1.52] | [−0.57] |
| LVAU | $3.55^{**}$ | 0.92 | LVAU | $0.07^{**}$ | 0.02 |
| | (1.59) | (0.87) | | (0.03) | (0.04) |
| | [2.23] | [1.05] | | [2.16] | [0.58] |
| PROB | 1.51 | 0.64 | PROB | −0.03 | −0.01 |
| | (1.48) | (1.61) | | (0.04) | (0.03) |
| | [1.02] | [0.39] | | [−0.58] | [−0.44] |
| Lagged inflation | | $0.82^{***}$ | Lagged $d$ | | $0.64^{***}$ |
| | | [13.78] | | | [8.28] |
| Method | LS | LS | Method | GLS | GLS |

Notes: Coefficients' standard errors in parentheses, and $t$-statistics in square brackets. $^{***}$, $^{**}$, $^{*}$ indicate results significant at the 1%, 5%, and 10%, respectively.
Abbreviations: Least Square (LS); Generalized Least Square (GLS).

Data mining, like averaging of time series, can affect estimation results. It happens due to loss of information during such data modification. For example, in time series regressions involving quarterly data, such data are often derived from the monthly data by simply adding three monthly observations and dividing the sum by three. This averaging introduces smoothness into the data by reducing fluctuations in the monthly data (Gujarati 2003, p. 447). The presence of outliers and/or influential points can dramatically affect the regression line. This means that these points are capable of

pulling the regression line toward itself, thus distorting the slope of the regression line. In order to show effects of both situations, Table 5 presents panel data estimation (only for CBI measures) based on four periods (averages of decades between 1970–2007), with or without influential observation. In general literature on CBI, it is accepted to believe that Germany and Switzerland could be influential points. The model is defined in the same way throughout all estimations.

**Table 5.** Estimation results for industrial countries using averaged data

| | GMTO | GMTE | GMTP | LVAU | PROB | TOR |
|---|---|---|---|---|---|---|
| CBI | $-9.35^{***}$ | $-8.30^{***}$ | $-6.93^{***}$ | $-8.87^{***}$ | $9.15^{***}$ | $11.55^{**}$ |
| | (0.79) | (0.81) | (0.75) | (2.31) | (1.64) | (4.02) |
| | [−11.76] | [−10.24] | [−9.23] | [−3.83] | [5.59] | [2.88] |
| Less D and CH | | | | | | |
| CBI | $-9.09^{***}$ | $-8.04^{***}$ | $-6.80^{***}$ | $-8.23^{**}$ | $8.3^{***}$ | 2.36 |
| | (1.00) | (1.1) | (0.91) | (2.84) | (1.97) | (6.34) |
| | [−9.01] | [−7.24] | [−7.49] | [−2.89] | [4.19] | [0.37] |

Notes: Least square, fixed effects with White cross-section coefficient covariance method. Coefficients' standard errors in parentheses, t-statistics in square brackets. $^{***}$, $^{**}$, $^{*}$ indicate results significant at the 1%, 5%, and 10%, respectively.
Abbreviations (used hereinafter): TOR index created by Cukierman et al. (1992); Less D and CH means that estimations are without Germany and Switzerland.

Averaging data appears to significantly affect the estimations' results. The key difference comes from the fact that now all measures have perfect explanatory power of the change in inflation across countries and time. Not only do legal measures of independence matter, but so do those so-called "actual" measures connected with a change (or probability of a change) of a CB governor. Much higher coefficients (often, ten times larger than produced in the annual analysis) can be connected with the data modification; now, CBI is related to decennial change in inflation rate. However, comparing annual versus decennial data analysis, one should notice much larger standard errors of estimated coefficients in the latter type, especially with LVAU, PROB and TOR. Elimination of influential points does not bring big differences in estimations. Coefficients values decrease slightly, standard errors increase, but all the measures have strong explanatory power, except the turnover rate of governors.

### 4.2 CBI in emerging markets

A few emerging markets, especially those from Latin America, are characterised with short periods of very high inflation (Table 6 presents descriptive statistics for some countries). Argentina, Brazil or Peru are countries where the inflation rate was measured in thousands of percentage points (its annual change). As explained earlier, one of the solutions to these data is to represent a dependent variable as a transformed inflation, as suggested by Cukierman (1992). This treatment, however, as pointed out by Jácome and Vázquez (2005), has an undesirable effect of bounding the dependent variable in the interval [0,1]. For this reason, the alternative measure, $\log(k+\pi)$ is

applied. The variable $k$ is a positive number that helps avoid finding a logarithm from a negative number. Because of Thailand's example with a negative inflation rate of $-9.5\%$ in the 1990, $k$ is number 10.

**Table 6.** Descriptive statistics of inflation for selected emerging countries

| Country | Obs | Mean | S.D. | Min | Max |
|---|---|---|---|---|---|
| Argentina | 28 | 295.17 | 709.29 | −1.17 | 3079.46 |
| Brazil | 28 | 424.54 | 760.02 | 3.21 | 2947.73 |
| Chile | 28 | 12.71 | 9.66 | 1.06 | 35.14 |
| Peru | 28 | 461.02 | 1518.67 | 0.16 | 7481.69 |
| Thailand | 28 | 4.01 | 4.73 | −9.50 | 19.70 |
| Venezuela | 28 | 30.62 | 22.63 | 6.24 | 99.88 |

Availability of data on CBI in emerging markets allows to perform this analysis for the years 1980–2007. The estimated model looks different than the one for industrial countries, for example. One finds it reasonable to include certain variables describing institutional developments among emerging countries. These can relate to political regimes, like the number of veto players in the parliament (checks and balances), or can describe economic conditions, such as presence of banking sector reforms, for example. Among many such variables, the final model includes a level of world inflation rate, a dummy variable for periods of hyperinflation and a variable describing the degree of economic freedom:

$$\begin{aligned} \log y_{it} &= \alpha + \beta_1 CBI_{it} + \beta_2 \log y_{it-1} + \beta_3 Worldinflation_{t-1} \\ &\quad + \beta_4 DummyHyperinflation_{it} + \beta_5 Econfreedom_{it} + u_{i,t} \end{aligned} \tag{4}$$

A dummy for hyperinflation considers countries and periods when inflation was above certain level. This level can be set arbitrarily. However, an example given by Peltonen (2006) has been used: hyperinflation when average inflation rate is above 40%. An index of economic freedom has been constructed by the Fraser Institute (Gwartney et al. 2006). The index comprises 21 components designed to identify the consistency of institutional arrangements and policies with economic freedom in five major areas: size of government; legal structure and security of property rights; access to sound money; freedom to trade internationally; and regulation of credit, labor and business. The index ranges from 0–10, where 0 corresponds to less economic freedom and 10 to more economic freedom.

The estimation procedure starts with the simple bivariate model, where CBI measure is the only regressor. This is done, although not reported here, to verify results obtained from previous studies. Many of the first studies use the CBI index as the only independent variable and obtain significant results describing a relation between higher CBI degree and lower inflation rates. These outcomes were also confirmed here. In bivariate models, all five measures (TOR, GMTE, GMTP, GMTO and LVAU) have a strong explanatory power of inflation levels among emerging markets.

**Table 7.** Estimation results for emerging markets: log inflation as a dependent

| | LVAU | GMTO | GMTE | GMTP | TOR | TOR |
|---|---|---|---|---|---|---|
| CBI | −1.02 | −0.10 | −0.13** | 0.04 | 0.37*** | 0.34*** |
| | (0.07) | (0.09) | (0.04) | (0.08) | (0.09) | (0.09) |
| | [−1.57] | [−1.14] | [−2.85] | [0.47] | [4.20] | [3.72] |
| logI(−1) | 0.67*** | 0.67*** | 0.66*** | 0.67*** | 0.62*** | 0.65*** |
| | (0.07) | (0.07) | (0.07) | (0.06) | (0.06) | (0.09) |
| | | | | | | [7.05] |
| WI(−1) | 0.01*** | 0.01*** | 0.01** | 0.01*** | 0.01*** | 0.003*** |
| | (0.002) | (0.001) | (0.001) | (0.001) | 0.002 | (0.001) |
| | | | | | | [1.71] |
| Obs. | 450 | 450 | 450 | 450 | 450 | |
| | LVAU | GMTO | GMTE | GMTP | TOR | |
| CBI | −0.07 | −0.16* | −0.12** | 0.01 | 0.59*** | |
| | (0.08) | (0.09) | (0.05) | (0.07) | (0.09) | |
| | [−0.88] | [−1.85] | [−2.65] | [0.19] | [6.48] | |
| Hyperinflation | 0.84*** | 0.85*** | 0.84*** | 0.87*** | 0.86*** | 0.51*** |
| | [0.08] | [0.08] | [0.08] | [0.089] | [0.08] | [2.81] |
| CBI | 0.06 | 0.02 | −0.02 | 0.11* | 0.49*** | |
| | [0.79] | [0.25] | [−0.55] | [1.80] | [5.87] | |
| Econfreedom | −0.10*** | −0.10*** | −0.09*** | −0.11*** | −0.05*** | −0.06** |
| | | | | | | [−3.46] |
| Method | | | | | | 2SLS/EGLS |

Notes: Coefficients' standard errors in parentheses, t-statistics in square brackets. ***, **, * indicate results significant at the 1%, 5%, and 10%, respectively.
Abbreviations: natural logarithm of inflation (logI ); world inflation (WI); dummy for countries and years with inflation rate over 40% (Hyperinflation); index of economic freedom (Econfreedom); Two Stage Least Square (2SLS).

One treatment to account for the possible endogeneity in the regression is the use of instrumental variables. A method of Two Stage Least Squares (TSLS) has been used, the result of which can be found in the last column of Table 7. When the turnover rate of governors as a CBI proxy is used, as before the results indicate that inflation in the sampled countries is positively correlated with world inflation, negatively correlated with the index of economic freedom and positively correlated (as expected) with the measure of CBI. The list of instruments include lagged inflation (lags 2, 3), economic freedom indicator (lags 1, 2), world inflation rate (lag 2), dummy for hyper inflation (lag 1) and one period lag of TOR.

After checking the robustness of the estimation by including explanatory variables, it is again time to re-define the dependent variable and use the variable $d$-transformed inflation values. The procedure is repeated; analysis starts with bivariate models to end the model, including both index of economic freedom and a dummy for hyperinflation. Effects of CBI measures are now smaller, in the sense that only turnover of governors scores the expected sign and is significantly different from zero for most of

the estimation's transformations. For simplicity, Table 8 reports values only for CBI indices.

**Table 8.** Estimation results for emerging markets: "transformed inflation" as a dependent

| Dependent: $d$ | LVAU | GMTO | GMTE | GMTP | TOR |
|---|---|---|---|---|---|
| CBI | $-0.07^{**}$ | $-0.05^{**}$ | $-0.04^{**}$ | $-0.02$ | $0.15^{***}$ |
| | (0.02) | (0.02) | (0.01) | (0.02) | (0.04) |
| | [−2.82] | [−2.18] | [−2.48] | [−0.85] | [4.19] |
| With $d(-1)$ and world inflation | | | | | |
| CBI | −0.001 | $0.05^{*}$ | 0.01 | $0.05^{**}$ | $0.07^{**}$ |
| | (−0.041) | (1.82) | (0.68) | (2.09) | (3.08) |
| | [0.02] | [0.03] | [0.01] | [0.02] | [0.03] |

Notes: Coefficients' standard errors in parentheses, t-statistics in square brackets. $^{***}$, $^{**}$, $^{*}$ indicate results significant at the 1%, 5%, and 10%, respectively.

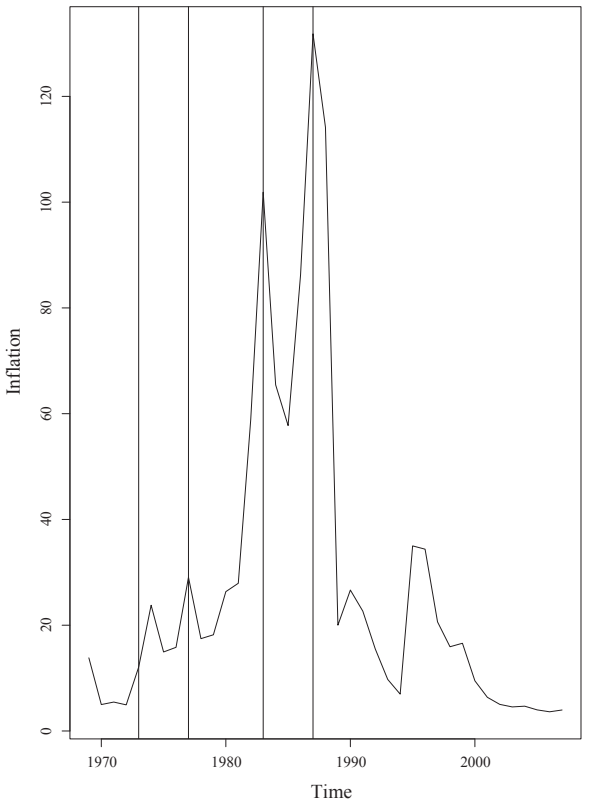
It is also possible to do another type of robustness analysis. Certainly, it is by now obvious that estimation outcomes depend on the type of countries. The relation between degree of CBI and inflation rate is much stronger among advanced countries than emerging ones, for example. This strength lies mainly in the fact that this relation is visible with many different definitions of CBI.

### 4.2.1 CBI in a few Latin American countries

Among emerging markets, it is plausible to distinguish a separate group of countries. Some papers, such as Jácome and Vásquez (2005), for example, focus only on Latin American countries. Here, those countries are Argentina, Brazil, Chile, Peru, Mexico and Venezuela. Therefore, the following analysis will include only these six countries.

Table 6 with descriptive statistics for these countries, clearly indicates that almost all of them experienced periods of hyperinflation. In the 1990s, these countries experienced waves of currency and banking crises. Mexico registered major exchange rate devaluations in both in the 1980s and 1990s. Argentina and Venezuela faced additional banking crises in 2002 and 1994–1995, respectively. At the same time, many of these countries had undergone fundamental changes to their political and economic structures since the 1980s.

Increasing degrees of central bank independence aimed to create a credible message to the public concerning a reduction in inflation rates. Prior to the 1990s, for example, Mexico suffered bursts of inflation after several failed inflation-fighting programmes (Gould and Marion 1998). Figure 2 presents a history of inflation rate with, vertical lines marking years in which an anti-inflation programme was introduced. As Figure 2 shows, during the 1970s and 1980s, anti-inflation programmes implemented at inflation peaks were eventually abandoned, succeeded by a new acceleration of inflation rate.




Source: IMF statistics and Gould and Marion (1998)

**Figure 2.** Inflation rate in Mexico

Past and recent experience of governors of the Central Bank of Argentina prove that changing legislation is not enough for the rule to be enforced. In fact, central bank governor, Martin Redrado was recently dismissed from his position for refusing to repay the country's international debt from the central bank's funds. This is an example of the discrepancy between legal and actual degree of central bank independence, often observed in non-advanced countries. The above analysis has shown that the turnover rate of governors, an example of the measure of the actual degree of CBI, is mainly (if not solely) significantly able to explain changes in the level of inflation among emerging markets. Jácome and Vásquez (2005) showed that, in some cases, legal measures can also be a reliable independent variable among Latin American countries. Table 9 summarizes the verification of these hypothesis and results.

In a group of six Latin American countries, all CBI indices appear to have a strong explanatory power of inflation rate. Not only TOR, but all legal measures have their

**Table 9.** Estimation results for selected emerging markets

| Dependent: log inflation | LVAU | GMTO | GMTE | GMTP | TOR |
|---|---|---|---|---|---|
| CBI | $-0.84^{**}$ | $-0.47^{**}$ | $-0.29^{**}$ | $-0.50^{**}$ | $0.40^{**}$ |
| | (0.27) | (0.17) | (0.11) | (0.24) | (0.18) |
| | [−3.16] | [−2.74] | [−2.73] | [−2.14] | [2.23] |
| log $y_{i,t-1}$ | $0.56^{***}$ | $0.60^{***}$ | $0.60^{***}$ | $0.60^{***}$ | $0.57^{***}$ |
| | (0.10) | (0.11) | (0.11) | (0.11) | (0.11) |
| World inflation(−1) | $0.006^{**}$ | 0.002 | 0.002 | $0.005^{*}$ | $0.006^{**}$ |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Hyperinflation | $0.59^{***}$ | $0.71^{***}$ | $0.67^{***}$ | $0.73^{***}$ | $0.78^{***}$ |
| | (0.18) | (0.18) | (0.18) | (0.18) | (0.18) |
| Observations | 150 | 150 | 150 | 150 | 150 |
| CBI | $-0.65^{**}$ | $-0.37^{**}$ | $-0.22^{**}$ | $-0.40^{*}$ | $0.26^{*}$ |
| | [−2.57] | [−2.66] | [−2.64] | [−1.97] | [1.92] |
| Econfreedom | −0.06 | −0.09 | $-0.0989^{*}$ | $-0.11^{*}$ | −0.09 |
| | [−0.92] | [−1.59] | [−1.66] | [−1.87] | [−1.44] |

Notes: Coefficients' standard errors in parentheses, t-statistics in square brackets. $^{***}$, $^{**}$, $^{*}$ indicate results significant at the 1%, 5%, and 10%, respectively.

estimated coefficients significantly different from zero. It remains so even after including another independent variable—economic freedom index.

### 4.2.2 Some specification tests

Estimations results for emerging markets and a narrow group of Latin American countries show that the effect of central bank independence on the inflation rate was slightly different. While only a few CBI indices turn out to be significant regressors among nineteen varying countries (from Argentina, through India to South Africa), all five measures enter significant (and with expected signs) regressions for Latin America.

To test the robustness of these results, especially the strength of CBI measures explanatory power, a few tests are performed: a *J*-test for non-nested models, a model including only CBI measures and a stepwise selection of these measures. For all tests, log *inflation* is the dependent variable.

The *J*-test for non-nested models is performed in the same way as the one for industrial countries. Regressions include lagged dependent variable, lagged world inflation rate, dummy variable for hyperinflation and a measure of economic freedom. The first tests included all nineteen emerging markets. The hypothesis that the model with TOR is one of the regressors is accepted; fitted values of TOR entered significantly into all other models. Additionally, economic measure of GMT was able to exclude the model with its political counterpart.

As explained, estimation results were slightly different for only six Latin American countries. Therefore, the *J*-test for non-nested models is repeated for this group. From the original estimation results, it has been determined that economic freedom has a weaker explanatory power. At first, this variable was excluded from the regression during the test. As a result, only the legal measure of independence LVAU entered

significantly (though, at the 5% level) into all competing models. Reinserting the economic freedom variable weakened the effect of LVAU, and it was not possible to point at any model to be accepted.

The next two tests are similar in assumptions. Both accept only CBI measures as regressors. The summary of results from estimations, including only measures taken altogether, can be found in Table 10. Again, GMTO is excluded, being in the strongest correlation with both its sections: economic and political. The Durbin-Watson statistic (0.55), as expected, indicates positive autocorrelation.

**Table 10.** Estimation results for selected emerging markets: CBI as regressors

| Dependent: log inflation | LVAU | GMTE | GMTP | TOR |
|---|---|---|---|---|
| | −1.53 | −1.01 | 1.51 | 1.46 |
| | [−3.02] | [−2.76] | [4.51] | [3.61] |

Notes: t-statistics in square brackets.

The estimation coefficients are obtained with the Least Squares method but, Generalised LS has supported these results. Among all estimations, the positive (unexpected) sign of GMT political is the most surprising. As a reminder, it describes procedures for appointing and dismissal of the central bank's governor and the Monetary Policy Committee. In this way, it is related to the turnover rate of governors, which also describes the change in the office of the CB governor. Although the TOR's construction determines that the relation with inflation rate is expected to be positive, values of GMTP are expected to produce a negative coefficient of estimation.

A stepwise selection method of regression indicates clearly that it is again TOR that is included as the first regressor with adjusted $R^2$ at the level of 0.24. LVAU is included in the next step improving the regression fit by 0.03, whereas GMTP enters in the third place, again with a positive sign. All in all, it indicates that in a group of emerging markets it is a measure of the "actual" independence (TOR) that explains changes in the inflation rate most accurately.

### 4.3 CBI among developing countries

The group comprising all developing countries is very diversified. In fact, it includes approximately seventy countries, among which it is possible to create several subgroups. Very few measures have been calculated for these countries. It is reasonable (based on the size sample) to include only two: TOR and the overall GMT index. Both represent two completely different definitions of central bank independence, so it is rational to perform a comparison between these two. These measures also allow for the analysis within the years 1980–2007.

Looking at the list of countries in Table A1 in the Appendix, one notices a wide variety among them. One common characteristic is a rather unstable political situation among these nations. Many of them have recorded periods of hyperinflation, whereas some have had years of negative inflation. Several summarising statistics regarding the inflation rate can be found in Table 11.

**Table 11.** Descriptive statistics of inflation for selected developing countries

| Country | Obs | Mean | S.D. | Min | Max |
|---|---|---|---|---|---|
| Cambodia | 21 | 30.46 | 55.89 | −31.25 | 191.00 |
| Haiti | 28 | 10.55 | 23.14 | −95.44 | 42.56 |
| Maldives | 28 | 6.47 | 7.67 | −9.16 | 27.88 |
| Mozambique | 28 | 30.93 | 32.06 | 1.49 | 164.12 |
| Nicaragua | 24 | 83.01 | 206.80 | 3.70 | 885.20 |

In a group of countries with such a large variance in their inflation rate, it is difficult to find a proper representation. Nevertheless, it is believed that a transformed measure of inflation, $d = \textit{inflation rate}/(1+\textit{inflation rate})$, would well represent changes in the inflation rate (with a natural logarithm of inflation rate as a robustness check).

The choice of explanatory variables in the following estimations was based on a condition of the (in)stability of economies. A level of GDP per capita or a degree of openness may have rather limited effect in countries affected by many political and/or military conflicts. For this reason, one of the considered variables is the number of conflicts in which the government of the country is involved, from UCDP/PRIO Armed Conflict Dataset (Gleditsch et al. 2002). This variable's minimum value is (0) and the maximum depends on the number of observed conflicts in a single year (very often it is (1), but not always). It is expected that a larger number of conflicts introduces destabilisation in the market and may be positively correlated with a higher inflation rate. A measure describing a degree of economic freedom is also considered in the model.

Finally there are two alternative models, for which estimation results can be found in Table 12. One includes proxies for conflict and economic freedom. The second replaces economic freedom with a dummy for hyperinflation and a possible effect of world inflation on the domestic rate.

Estimations, where a natural logarithm of inflation rate is the dependent variable, are performed using a Least Square estimator. Results are rather unstable in this group of countries. Therefore, estimations are also repeated with a GLS method. Again, surprisingly in respect to theory and previous studies claiming that TOR is the right proxy for developing countries, its coefficient records a negative sign (although it depends on the model and method used). GLS, in general, is able to "produce" the expected sign for TOR. In comparison with previous studies, Cukierman et al. (1992) reported a negative relationship between legal CBI and inflation for industrial countries, but failed to obtain similar results for developing countries. De Haan and Kooi (2000), using the turnover of central bank governors as a more direct measure of effective CBI for a sample of 82 countries in the 1980s, also failed to find a robust relationship between CBI and inflation.

Results of estimations with a transformed inflation rate as the dependent variable are quite similar to previous ones. GMT, again, proves to be a good regressor of the modified inflation rate. Now, TOR looses the negative sign in all estimations. It enters

the model significantly, however, only with a hyperinflation dummy and values for the world inflation rate.

**Table 12.** Results for industrial countries with CBI as the only regressors

| Dependent variable: log inflation | | | Dependent variable: transformed inflation | | |
|---|---|---|---|---|---|
| | GMT | TOR | | GMT | TOR |
| CBI | $-0.14^{**}$ | $-0.01$ | CBI | $-0.15^{*}$ | $0.03^{**}$ |
| | (0.07) | (0.01) | | (0.06) | (0.01) |
| | [−2.07] | [−0.88] | | [−2.33] | [2.25] |
| Inflation(−1) | $0.67^{***}$ | $0.49^{***}$ | Transformed | $0.63^{***}$ | $0.48^{***}$ |
| | (0.13) | (0.05) | inflation(−1) | (0.11) | (0.04) |
| Conflict | $0.05^{**}$ | 0.005 | Conflict | 0.03 | $0.01^{***}$ |
| | (0.02) | (0.006) | | (0.01) | (0.005) |
| Econfreedom | $-0.04^{**}$ | $-0.02^{***}$ | Hyperinflation | $0.06^{*}$ | $0.11^{*}$ |
| | (0.01) | (0.003) | | (0.05) | (0.06) |
| | | | World inflation | $0.002^{***}$ | $0.001^{***}$ |
| | | | | (0.0007) | (0.0002) |
| Obs. | 728 | 859 | | 919 | 1134 |
| Countries | 47 | 36 | | 63 | 48 |
| Adjusted $R^2$ | 0.63 | 0.99 | | 0.63 | 0.99 |
| Method | LS | GLS | | LS | GLS |

Notes: Coefficients' standard errors in parentheses, t-statistics in square brackets. $^{***}$, $^{**}$, $^{*}$ indicate results significant at the 1%, 5%, and 10%, respectively.

Abbreviation: Conflict is measure of number of conflicts in the region.

**Table 13.** Estimation results for developing countries using instrumental methods

| Dependent: Transformed inflation | TOR | GMT |
|---|---|---|
| CBI | $0.03^{**}$ | $-0.01^{**}$ |
| | (0.09) | (0.008) |
| | [2.81] | [−1.66] |
| Transformed inflation(−1) | 0.84 | 0.84 |
| | (0.03) | (0.04) |
| Conflict | 0.004 | 0.007 |
| | (0.006) | (0.004) |
| Obs. | 1037 | 834 |
| Countries | 48 | 63 |

Notes: 2SLS/EGLS method. Coefficients' standard errors in parentheses, t-statistics in square brackets. $^{***}$, $^{**}$, $^{*}$ indicate results significant at the 1%, 5%, and 10%, respectively.

Again, similar to the analysis for emerging markets, one may use the IV-estimation method. Results of the TSLS estimation method are included in Table 13. In a simple model, both measures prove to be good regressors of the dependent variable, showing that the degree of CBI also matters for the inflation rate among developing countries. The list of instruments includes lagged inflation (lags 2, 3), world inflation rate (lag 1), dummy for hyper inflation (lag 1), a measure of number of conflicts (lag 1) and one

period lag of the CBI measure. All in all, one can conclude that the group of developing countries is so diversified, with so many unstable regimes, that results are very much dependent on the list of other variables included in the model.

### 4.4 CBI in transition countries

Former socialist countries in Central and Eastern Europe (CEE) have been in the centre of research interest since the beginning of the 1990s. One result of this research is the creation of a large number of CBI measures. Besides "standard" measures, such as LVAU or GMT, the literature provides indices such as the modified legal index LVES (Cukierman et al. 2002), an index of CB independence and accountability calculated for former Soviet Union republics (Lybek), or two indices constructed by Loungani et al. (1997) that include only twelve transition countries.

The period of the analysis is relatively short (1990–2007), but ongoing institutional changes give opportunity to distinguish two periods: before and after introducing new central bank acts. New CB legislation had not been introduced right away in all countries. In some of them, such as Poland, the major increase in CB independence took place in 1997. However, there is a large number of measures that were calculated only once, and for this reason, a cross-section analysis will be the major one.

The political and economic regime change and the process of democratisation also affected the quality of statistical data. In some cases, definitions of observed variables have changed several times. For example, countries currently within the European Union need to follow European statistical standards. These all have an effect on the precision of data. For this reason, and to avoid a large amount of variability in statistics due to the change in definitions, an analysis is performed on the averaged data. One obvious justification for additional modification of the sample is the European Union membership of some countries. This allows transition countries to be divided into one group with total number of countries and another including only EU members (members as of January 2009). However, one may never be sure if an anti-inflationary process undertaken among the newest EU members was due to an increased degree of CBI, or due to the general adjustment process required before the membership.

To benefit from including all CBI measures prepared for transition countries, simple cross-country estimations are performed, with averaged data in the period 1995–2005. It is necessary to state that estimation coefficients are very vulnerable to a change in the model. A few "political" variables, which are typically used (as described earlier) in estimations, did not enter significantly into the model and did not improve goodness-of-fit of the estimation. Table 14 presents the results of the model:

$$\log(\textit{inflation rate})_i = \alpha + \beta_1 CBI_i + \beta_2 \log(GDP\ p.c.)_i + \beta_3 openness_i \qquad (5)$$

A cross-country analysis is done at the particular point of time. It includes averaged data and only one value of CBI. Therefore, it is not as informative as panel data, where "before-and-after" recorded data help to compare different periods in time. Table 14 has therefore limited value-added, although, as stated, many previous studies on CBI were based on this kind of estimation.

**Table 14.** Estimation results for transition countries

| | GMTO | GMTE | GMTP | LVAW | LVES | TORMAS |
|---|---|---|---|---|---|---|
| CBI | −4.18*** | −3.14*** | −2.87** | −1.55 | −1.62 | 5.35*** |
| | (0.89) | (0.69) | (1.11) | (1.00) | (0.93) | (1.04) |
| | [−4.7] | [−4.49] | [−2.59] | [−1.55] | [−1.74] | [5.12] |
| GDP p.c. | −0.58*** | −0.47*** | −0.72*** | −0.59** | −0.54** | −0.82*** |
| | [−4.46] | [−3.15] | [−4.86] | [−3.64] | [−2.67] | [−5.57] |
| Openness | 0.01** | 0.01** | 0.01* | 0.01* | 0.01 | 0.01** |
| | [2.58] | [2.17] | [2.05] | [1.91] | [1.48] | [2.22] |
| Obs. | 25 | 25 | 25 | 25 | 21 | 18 |
| Adjusted $R^2$ | 0.54 | 0.45 | 0.48 | 0.35 | 0.26 | 0.65 |
| D-W | 1.7 | 1.7 | 1.42 | 1.34 | 1.3 | 2.1 |
| | Freytag | CBIAccount | CBIDF | SIB | CBI−Index | |
| CBI | −4.5** | −0.16** | −0.29 | 0.33 | −0.38 | |
| | (1.42) | (0.06) | (1.07) | (1.8) | (1.72) | |
| | [−3.16] | [−2.87] | [−0.27] | [0.18] | [−0.22] | |
| GDP p.c. | −2.70*** | −0.37** | −0.82** | −0.81* | −0.95 | |
| | [−6.33] | [−2.48] | [−2.56] | [−2.05] | [−1.83] | |
| Openness | 0.02** | 0.004 | 0.004 | 0.003 | 0.00 | |
| | [3.46] | [0.46] | [0.43] | [0.32] | [0.004] | |
| Obs. | 10 | 15 | 12 | 12 | 13 | |
| Adjusted $R^2$ | 0.79 | 0.48 | 0.06 | 0.05 | 0.14 | |
| D-W | 1.35 | 2.9 | 0.46 | 0.49 | 0.99 | |

Notes: Coefficients' standard errors in parentheses, t-statistics in square brackets. White heteroskedasticity-consistent standard errors. ***, **, * indicate results significant at the 1%, 5%, and 10%, respectively.

Abbreviations: LVAW, LVES indices by Cukierman et al. (1992); TORMAS index by Cukierman et al. (1992) updated by Maslowska; Freytag constructed by Freytag (2003); CBIAccount index by Lybek (1999); CBIDF and SIB constructed by Loungani and Sheets (1997); CBIIndex by Freytag and Masciandaro (2005).

Estimated coefficients, as well as information on the goodness-of-fit of regressions, indicate that several measures do not have much explanatory power. These are measures by Loungani et al. (1997; CBIDF and SIB), index formulated by Freytag and Masciandaro (CBI-Index) or legal measures constructed by Cukierman et al. (1992) and Cukierman et al. (2002)—LVAW and LVES. After eliminating countries that recorded average inflation rate above 40%, few measures recorded significant and expected coefficients: GMTO, GMTP and TOR.

## 5. Conclusions

The major goal of this paper, choosing the most adequate CBI definition, is done by the empirical verification of impact on economy. The value added factor of this work is gathering and comparing various measures of independence. Moreover, although this paper is titled "Quest for the Best", indicating a "contest" among CBI measures, its general idea was to test if the strong negative relationship between CBI and inflation rate holds with the new data and new estimations' methods.

In the special edition of the European Journal of Political Economy, devoted to the phenomenon of central bank independence, Siklos (2008) argues that CBI should be interpreted as a collection of characteristics that are related to inflation. Consequently, he claims, there is no single definition of CBI that is "right" for all countries. This paper reaches the same conclusions after performing several empirical tests.

Measures of central bank autonomy offer a useful expression of the extent to which a central bank is able to keep the government away from influencing a change in the inflation rate. The more a measure represents this idea, the more easily one can find a relation between the CBI value and the inflation rate. For example, after many estimations, one can notice that proxies by Grilli et al. are very often strong regressors of inflation rate, contrary to those by Cukierman et al. This explanatory strength of GMT can be explained by the fact that existing indices, with the exception of the GMT index, tend to focus excessively on statutory aspects of CBI, while omitting non-statutory factors that influence the *de facto* degree of CBI (Siklos 2008). Therefore, it should come as no surprise that the measure of *de facto* CBI proves to be a significant explanatory variable among many countries where statutory aspects of CB autonomy matter to a lesser extent.

The group of advanced countries is the strongest example that the process of disinflation has been accompanied by the increasing degree of central bank independence. Long time span, several recorded changes in the degree of CBI with the upward trend and (despite financial turbulences at the beginning of the 1990s) decreasing inflation rate, all prove to be significant in the search for a negative relation between CBI and inflation. All measures performed as expected, indicating a negative relationship. However, additional tests of non-nested models showed that fitted values only for GMTO entered significantly into all other models, proving to be "superior" to all other CBI measures in this type of regressions.

The turnover rate of governors, the measure of so-called "actual" CBI, has proven to be a good regressor of inflation among emerging markets. Not surprisingly, after all, these countries' quality of democratic institutions should be described rather by the actual practice, not legal acts. More interestingly, however, measures of legal independence appeared to be rather good regressors within a group of Latin emerging countries. In a group of six Latin American countries, all CBI indices appear to have strong explanatory power of inflation rate. Not only TOR, but also all legal measures have their estimated coefficients significantly different from zero. It remained so even after including another independent variable—the economic freedom index. However, additional tests such as the *J*-test for non-nested models pointed to the TOR as the most accurate definition of central bank independence.

Analysis for developing and transition countries was rather limited, but gave some interesting outcomes. First of all, only two measures, TOR and GMT, provided data for a group of approximately 70 developing countries. Between these two measures, TOR estimated coefficients were rather vulnerable to applied tests. On the other hand, GMT proved to be a rather good regressor of inflation, even after the model's modifications. This type of measure also had a strong explanatory power within transition countries. Many other measures, including Loungani (1997), Eijffinger and Schaling (1995) or

measures by Cukierman et al. (1992, 2002), did not manage to prove that there is a negative relation between a degree of CBI and inflation rate in transition countries.

The analysis performed by Cukierman (1992), which led him to the conclusion that institutional differences among countries matter, not the measure used in the analysis, is one of the most influential in the history of studies on CBI and its relations with inflation. At the moment of his study, a limited number of CBI measures was available. One of the aims of this paper was to challenge this opinion. With considerably long time series and large cross-country data, as well as varying tests, it was possible to at least hint the idea that one may also obtain contradictory results within one sample of countries, when using "competing" CBI measures.

This study assumes that a proxy can become a good approximation of the definition if it is not vulnerable to data or specification change. It can be seen already within a rather homogenous group of industrial countries that some indices perform "better" than others. For example, legal proxies by Grilli, Masciandaro and Tabellini performed in the majority of tests as expected, while measures by Cukierman et al. (LVAU and TOR) were vulnerable to changes in the estimated models.

These results question the correctness of the fact that the most popular CBI measure used for further analysis is the legal measure by Cukierman (1992) and Cukierman et al. (1992), as reported recently by Klomp and de Haan (2010). The analysis presented here shows that there is no reason why this measure would be chosen more often than others, except for the usual argument that Cukierman's measure provides data for a larger number of countries and longer time series. This measure's major "rival" (i.e., the legal measure by Grilli et al. 1991) performed better in the statistical point of view.

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## Appendix

**Table A1.** List of countries: IMF classification based on 2007

| | |
|---|---|
| Industrial countries: | Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom, the United States |
| Transition countries: | Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Moldova, Mongolia, Poland, Romania, Russia, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan |
| Emerging countries: | Argentina, Brazil, Chile, Egypt, India, Indonesia, Israel, Jordan, Malaysia, Malta, Mexico, Morocco, Pakistan, Peru, Philippines, South Africa, Thailand, Turkey, Venezuela |
| Developing countries: | Algeria, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia, Botswana, Burundi, Cambodia, Cape Verde, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Ethiopia, Fiji, Ghana, Guatemala, Guinea, Guyana, Haiti, Honduras, Iran, Jamaica, Kenya, Kuwait, Lesotho, Libya, Madagascar, Malawi, Maldives, Mauritania, Mauritius, Mozambique, Myanmar, Nepal, Nicaragua, Nigeria, Oman, Panama, Papua New Guinea, Paraguay, Rwanda, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Solomon Islands, Sri Lanka, Sudan, Suriname, Syria, Tanzania, Trinidad and Tobago, Tunisia, Uganda, United Arab Emirates, Uruguay, Vanuatu, Vietnam, Zambia |

**Table A2.** Data sources of CBI measures

| Variables for CBI index | Source |
|---|---|
| GMTO, GMTE and GMTP | Grilli, Masciandaro and Tabellini (1991) and update from Arnone et al. (2004) |
| LVAU | Cukierman (1992), Cukierman et al. (1992) and update from Arnone et al. (2004) |
| TOR and VUL | Cukierman (1992), Cukierman et al. (1992) and update from Sturm and de Haan (2001) |
| TORMAS | author's own calculation in 2007 |
| PROB | Krause and Méndez (2007) |
| BP | Bade and Parkin (1988) |
| Alesina | Alesina (1988, 1989) |
| Alesina2 | Alesina (1988, 1989) and author's own update |
| ES | Eijffinger and Schaling (1993) |
| Distance | Fratianni and Huang (1994) |
| CBI-Index | Freytag and Masciandaro (2005) |
| OPCBI-N | Eijffinger and Schaling (1995) |
| CBI-DF | Loungani and Sheets (1997) |
| SIB | Loungani and Sheets (1997) |
| OI - overall independence | Maliszewski (2000) |
| Freytag | Freytag (2003) |
| CBI-Account | Lybek (1999) |

**Table A3.** Data sources of variables

| Variables for independent variables | Source |
|---|---|
| Inflation rate | OECD, IMF |
| World inflation rate | IMF |
| Hyper inflation dummy | Own calculations |
| GDP and GDP/capita (current prices) | OECD and IMF |
| Openness (current prices) | Penn World Tables |
| Economic freedom | Fraser Institute (Gwartney and Lawson 2006) |
| No of Conflicts | UCDP/PRIO Armed Conflict Dataset (Gleditsch et al. 2002) |